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(54) **APPARATUS AND METHODS FOR REAL TIME COMMUNICATION BETWEEN DRILL BIT AND DRILLING ASSEMBLY**

(75) Inventors: **Tu Tien Trinh**, Houston, TX (US); **Eric Sullivan**, Houston, TX (US)

(73) Assignee: **Baker Hughes Incorporated**, Houston, TX (US)

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This patent is subject to a terminal disclaimer.

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E21B 17/02	(2006.01)
E21B 10/00	(2006.01)
E21B 47/12	(2012.01)

(52) **U.S. Cl.**

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USPC **175/50**; 175/26; 175/24; 175/40; 324/369; 324/356; 340/853.6; 340/855.1; 367/81; 367/82; 367/83; 367/84; 367/85

(58) **Field of Classification Search**

CPC ... E21B 17/028; E21B 17/023; E21B 47/011; E21B 47/12; E21B 10/00

USPC 340/853.1, 853.6, 854.9, 855.1, 855.2; 324/369, 356; 175/26, 24, 40, 50; 367/81, 82, 83, 84, 85

See application file for complete search history.

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Primary Examiner — Jennifer H Gay

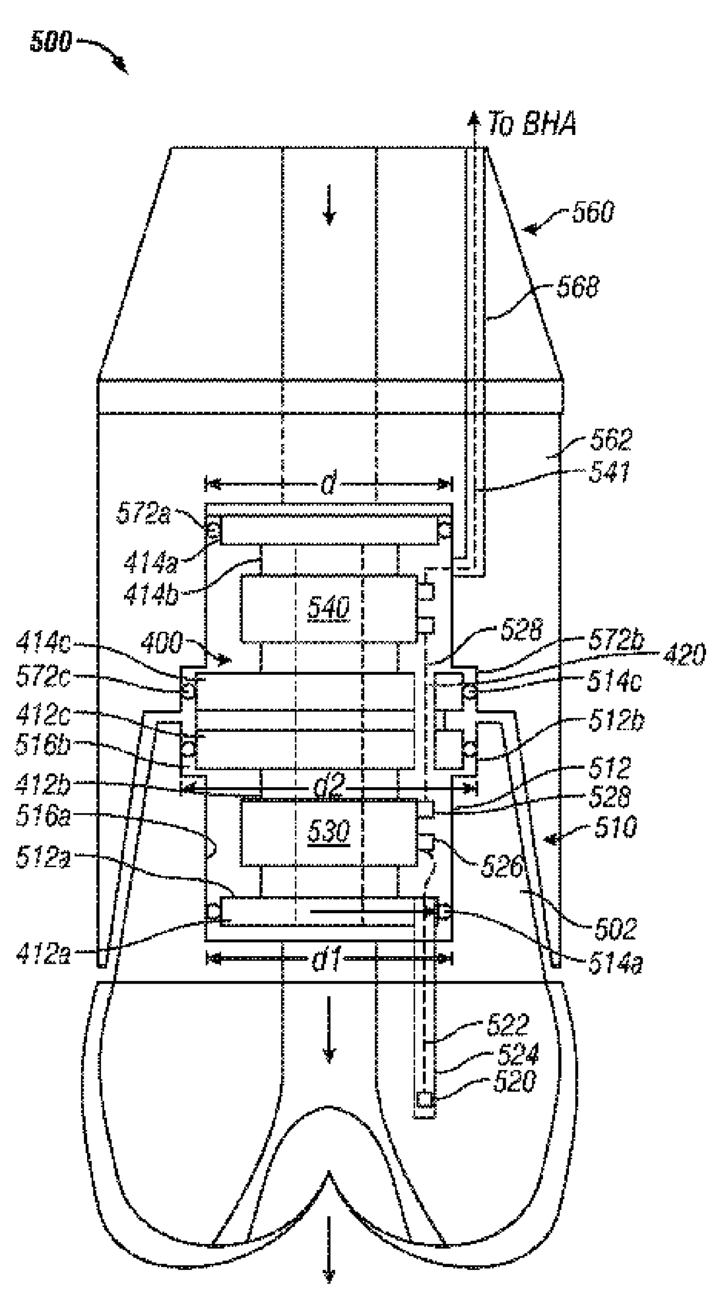
Assistant Examiner — George Gray

(74) *Attorney, Agent, or Firm* — Cantor Colburn LLP

(57) **ABSTRACT**

An apparatus and method of performing a wellbore operation. The apparatus includes a drill bit that has a cavity at an end thereof and a communication device placed in the cavity. The communication device includes a first section and a second section. An outer dimension of the second section is greater than an outer dimension of the first section. The second section includes a conduit configured to allow passage of a conductor from the drill bit to a location outside the drill bit so as to provide a direct connection of the conductor from the drill bit to an element outside the drill bit.

19 Claims, 6 Drawing Sheets



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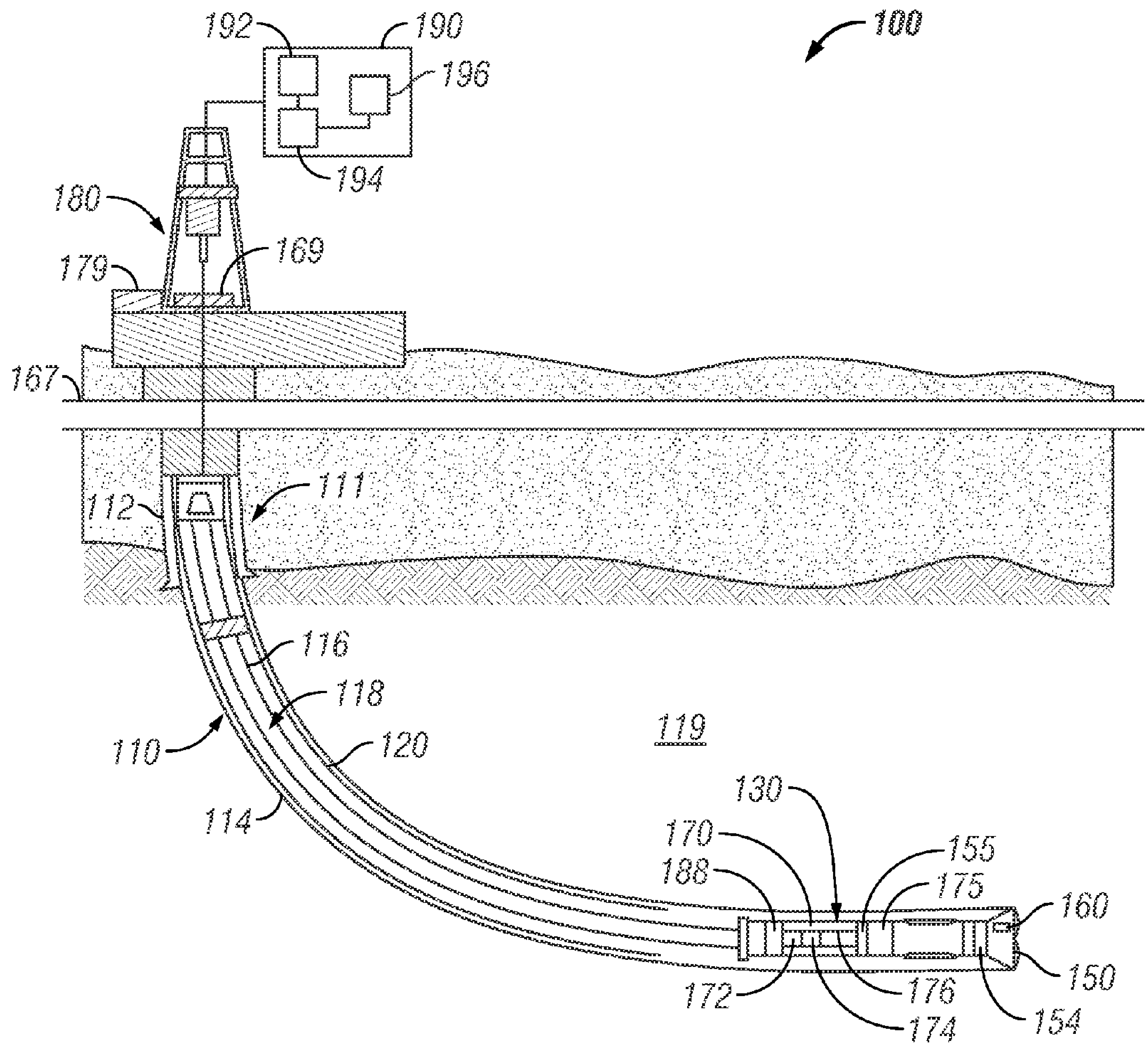
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192
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180
179
169
167
112
111
116
118
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120
114
130
170
155
188
175
160
150
172
176
174
154

FIG. 1

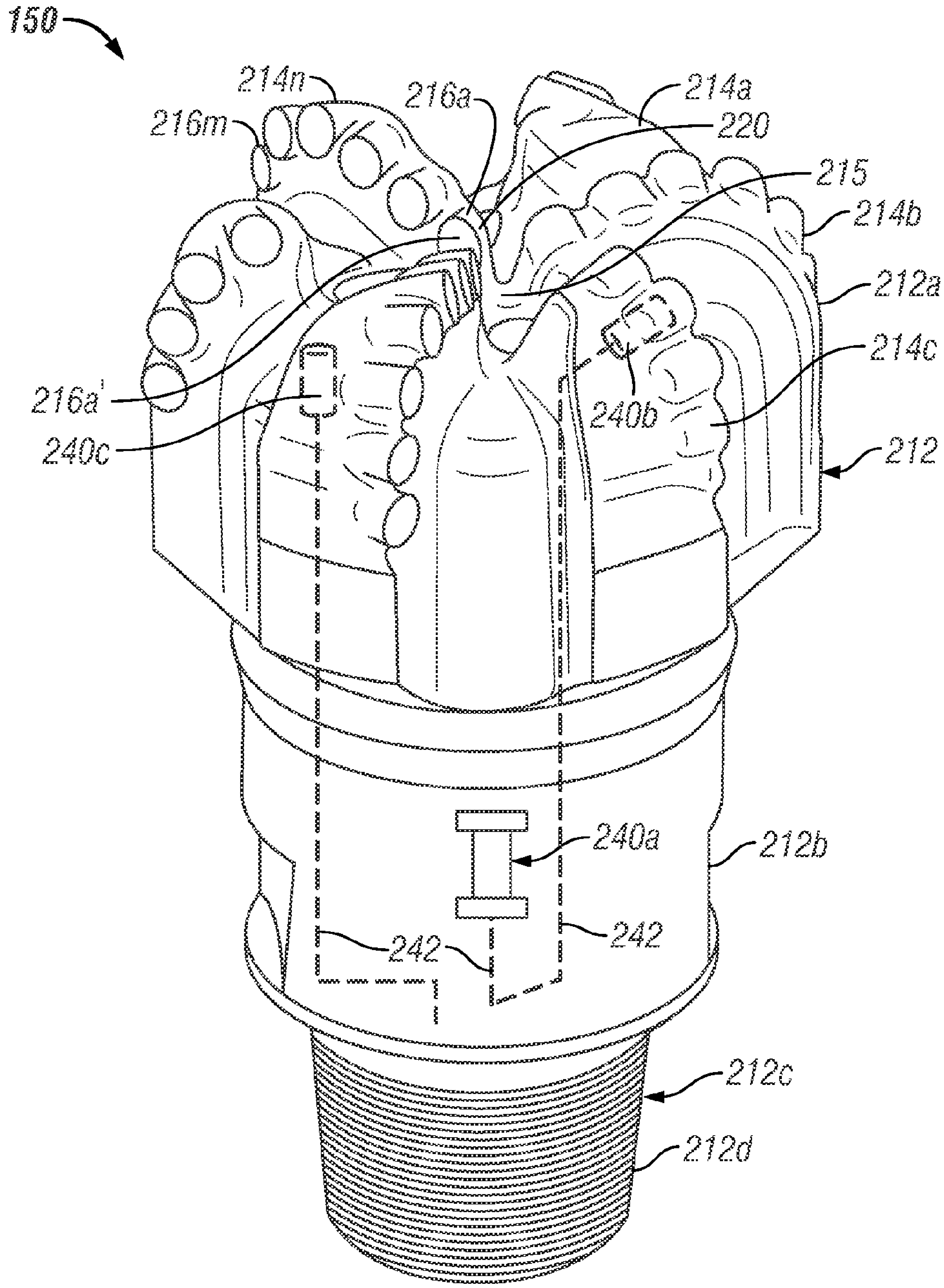
150
214n
216a
214a
216m
220
215
214b
212a
214c
216a'
240b
240c
212
240a
212b
242
242
242
212c
212d

FIG. 2

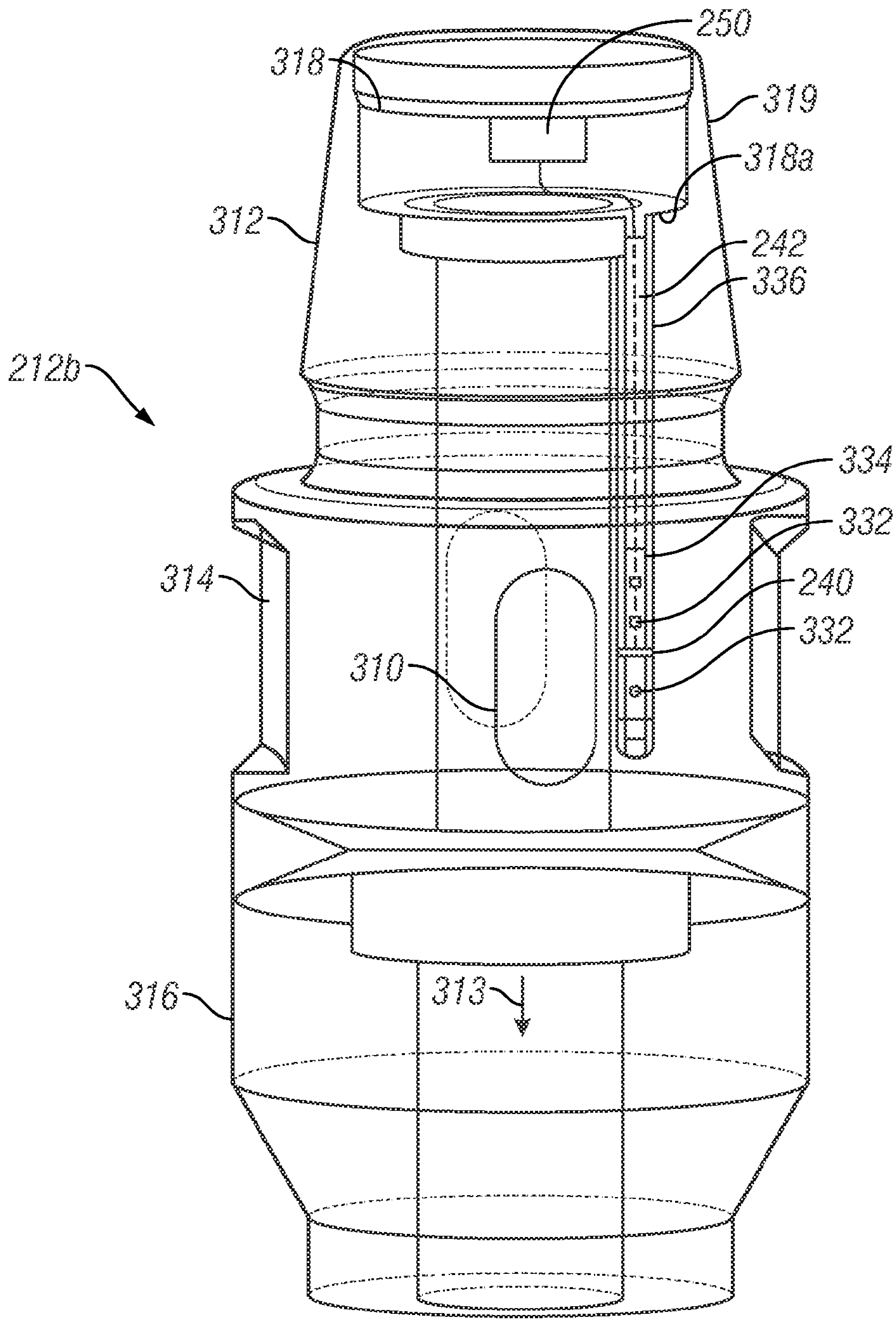
250
318
319
318a
312
242
336
212b
334
332
314
240
332
310
316
313

FIG. 3

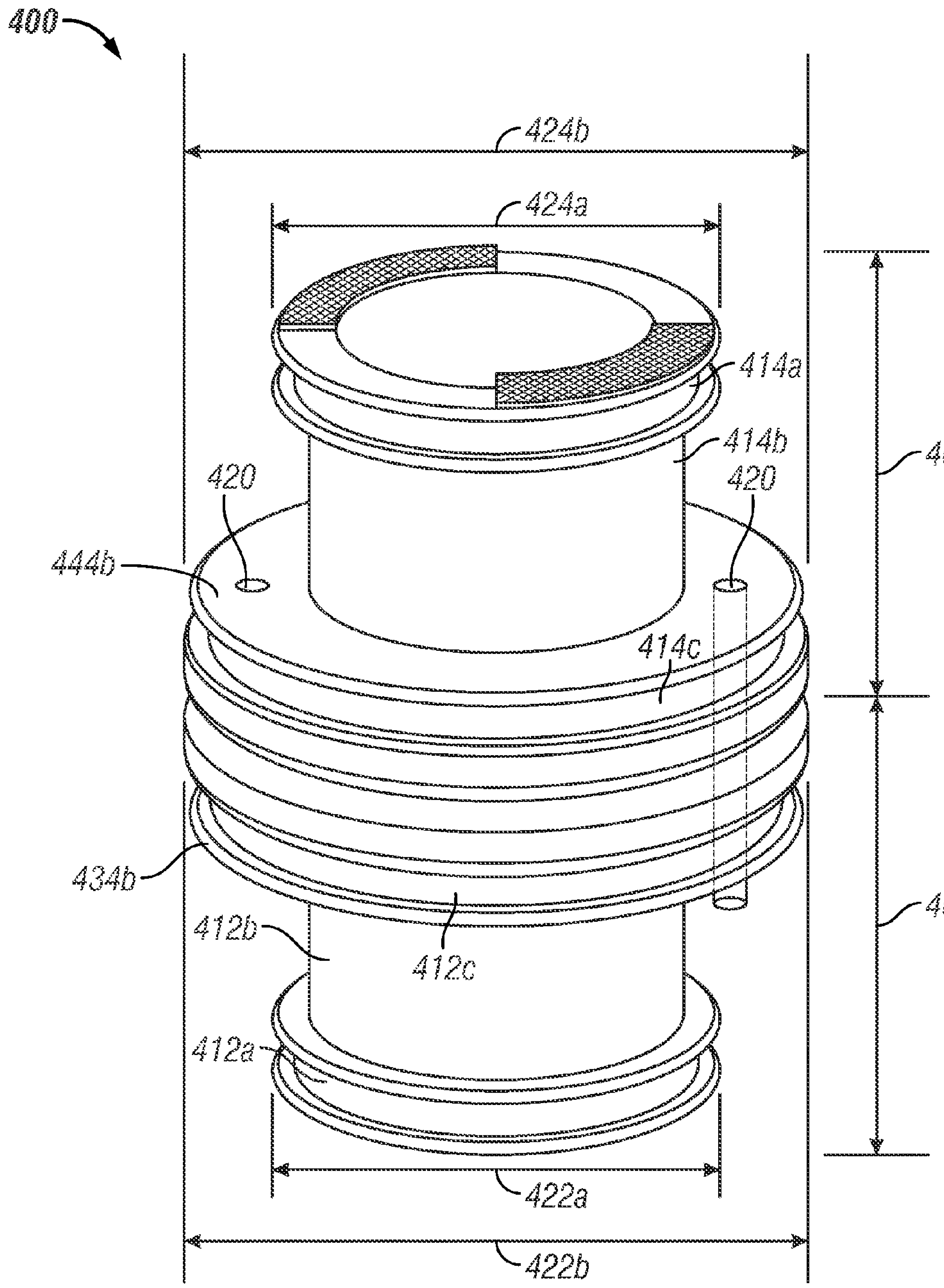
400
424b
424a
414a
414b
404
420
420
444b
414c
434b
402
412b
412c
412a
422a
422b

FIG. 4

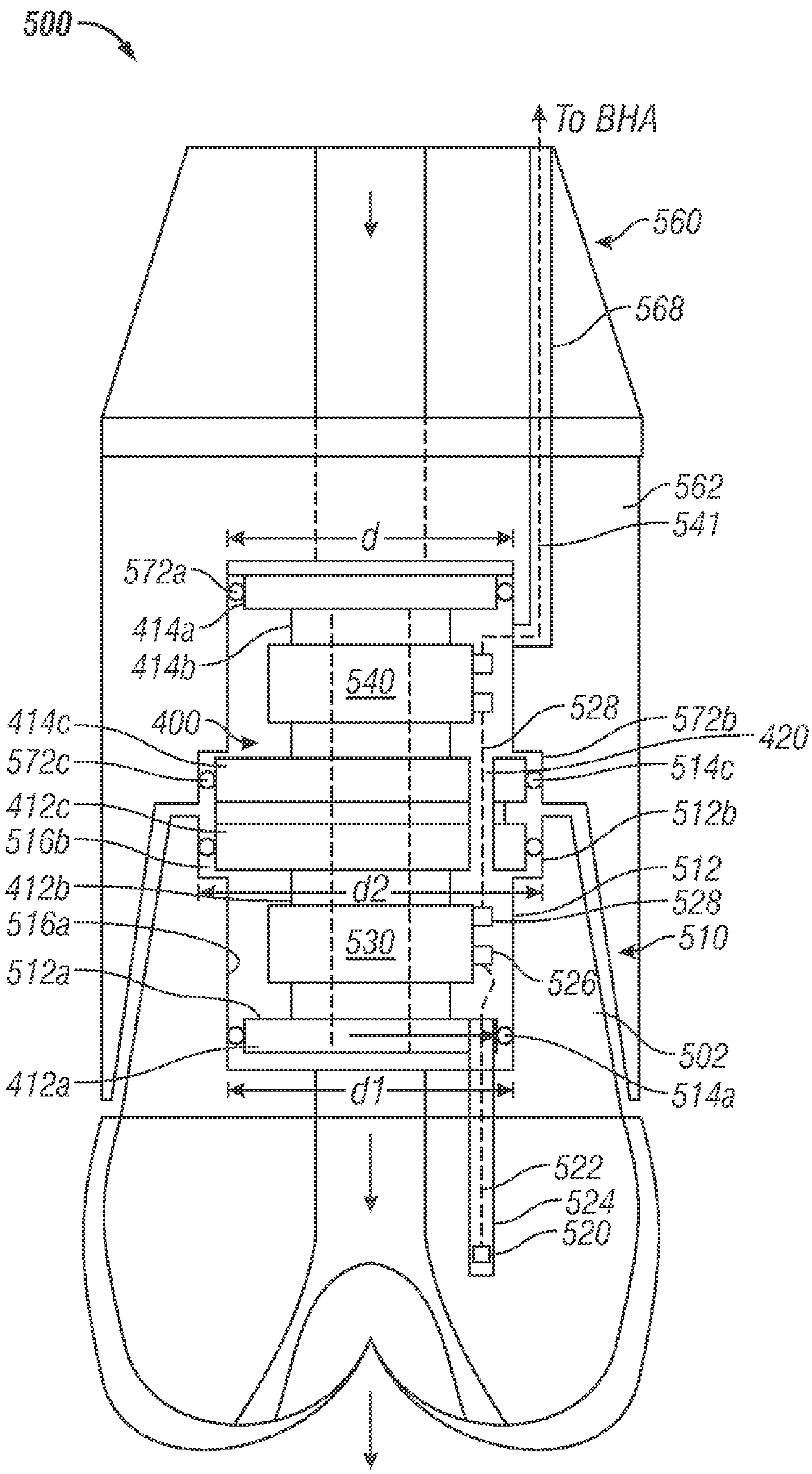
500
To BHA
560
568
562
541
d
572a
414a
414b
540
414c
400
528
572b
420
572c
514c
412c
512b
516b
412b
d2
512
528
516a
530
510
512a
526
502
412a
d1
514a
522
524
520

FIG. 5

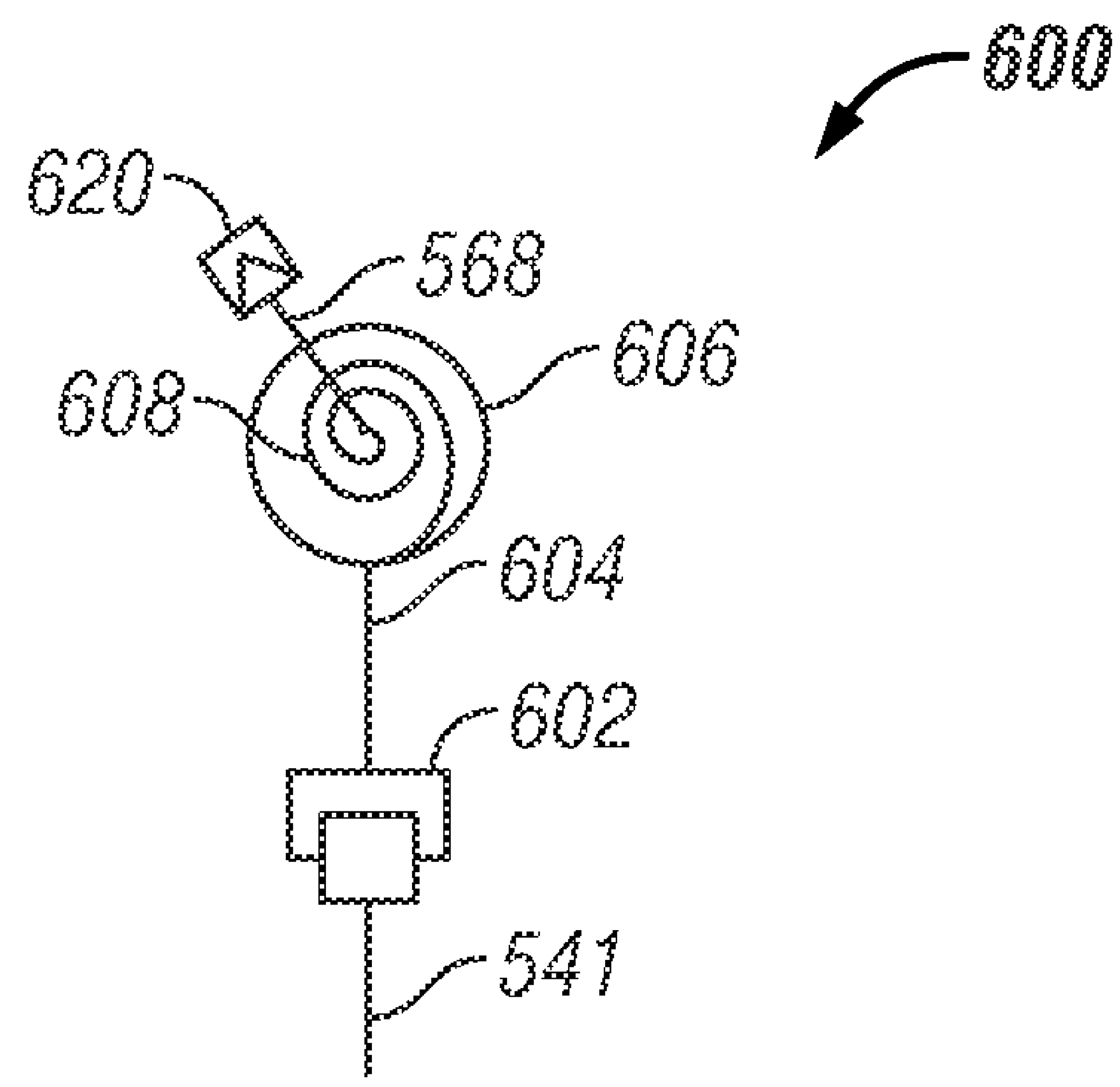

FIG. 6

APPARATUS AND METHODS FOR REAL TIME COMMUNICATION BETWEEN DRILL BIT AND DRILLING ASSEMBLY

CROSS REFERENCES TO RELATED APPLICATIONS

This application claims priority from the U.S. Provisional Patent Application having the Ser. No. 61/371,550 filed Aug. 6, 2010.

BACKGROUND INFORMATION

1. Field of the Disclosure

This disclosure relates generally to drill bits that include sensors for providing measurements and communication of measured and/or processed data to components in a drilling assembly attached to the drill bit.

2. Brief Description of the Related Art

Oil wells (wellbores) are usually drilled with a drill string that includes a tubular member having a drilling assembly (also referred to as the bottomhole assembly or "BHA") with a drill bit attached to the bottom end thereof. The drill bit is rotated to disintegrate the earth formations to drill the wellbore. The BHA includes devices and sensors for providing information about a variety of parameters relating to the drilling operations, behavior of the BHA and formation surrounding the wellbore being drilled (formation parameters). A variety of sensors, such as pressure sensors, inclinometers, sensor gamma ray sensors, etc. are embedded in the drill bit for providing information about various drilling and formation parameters. The data from the bit sensors is often stored in memory devices in the drill bit, which data is retrieved after tripping the drill bit out of the wellbore for further processing and use. It is desirable to transmit the bit sensor data and/or processed data from a circuit in the drill bit to the BHA and/or to the surface while drilling the wellbore, i.e., in real-time because the drill bit does not generally have adequate space for housing electronic circuitry to process large amounts of data. The BHA normally includes processors that can process copious amounts of sensor data and therefore it is economical to process the drill bit data in the BHA. Also, the drill bit is subjected to greater vibrations and thrust forces than certain parts of the BHA, where it is more desirable to locate the processors.

The disclosure provides an apparatus and methods for real-time communication of data and power between the drill bit and another device, such as a BHA, connected to the drill bit.

SUMMARY

An apparatus made according to one embodiment includes a drill bit that has a cavity at an end thereof and a communication device placed in the cavity, wherein the communication device includes a first section and a second section, wherein an outer dimension of the second section is greater than an outer dimension of the first section, and wherein the second section includes a conduit configured to allow passage of a conductor from the drill bit to a location outside the drill bit so as to provide a direct connection of the conductor from the drill bit to an element outside the drill bit.

Examples of certain features of the apparatus disclosed herein are summarized rather broadly in order that the detailed description thereof that follows may be better understood. There are, of course, additional features of the apparatus and method disclosed hereinafter that will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

For detailed understanding of the present disclosure, references should be made to the following detailed description, taken in conjunction with the accompanying drawings in which like elements have generally been designated with like numerals and wherein:

FIG. **1** is a schematic diagram of a drilling system that includes a BHA with a drill bit attached thereto and a communication apparatus between the drill bit and the BHA;

FIG. **2** is an isometric view of an exemplary drill bit showing placement of sensors in the drill bit and corresponding communication links to a neck of the drill bit;

FIG. **3** is an isometric line diagram of a shank of the drill bit of FIG. **2** showing placement of electronic circuit in a neck portion of the shank for processing drill bit sensor signals;

FIG. **4** is an isometric view of a communication link configured to house electronic circuitry and provide a passage for direct data and power connection between the drill bit and BHA;

FIG. **5** is a line diagram showing the communication link of FIG. **4** placed between a drill bit and another tool, such as a BHA, connected to the drill bit, according to one embodiment of the disclosure; and

FIG. **6** shows an auto-retractable device that may be utilized in the communication device for connecting conductors between the drill bit and another device, such as the BHA.

DESCRIPTION OF THE DISCLOSURE

The present disclosure relates to real-time communication between a drill bit and a device or tool coupled to the drill bit when the drill bit is in use. The present disclosure is susceptible to embodiments of different forms. The drawings show and the written disclosure describes specific embodiments of the present disclosure with the understanding that the disclosure is to be considered an exemplification of the principles of the disclosed herein, and that it is not intended to limit the disclosure to that illustrated and described herein.

FIG. **1** is a schematic diagram of an exemplary drilling system **100** that may utilize drill bits and data communication devices disclosed herein for use in drilling wellbores. FIG. **1** shows a wellbore **110** that includes an upper section **111** with a casing **112** installed therein and a lower section **114** that is being drilled with a drill string **118**. The drill string **118** includes a tubular member **116** that carries a drilling assembly **130** (also referred to as the bottomhole assembly or "BHA") at its bottom end. The tubular member **116** may be made by joining drill pipe sections or it may be a coiled-tubing. A drill bit **150** is attached to the bottom end of the BHA **130** for disintegrating the rock formation to drill the wellbore **110** of a selected diameter in the formation **119**. Not shown are devices such as thrusters, stabilizers, centralizers, and devices such as steering units for steering the drilling assembly **130** in a desired direction. The terms wellbore and borehole are used herein as synonyms.

Drill string **118** is shown conveyed into the wellbore **110** from a rig **180** at the surface **167**. The exemplary rig **180** shown in FIG. **1** is a land rig for ease of explanation. The apparatus and methods disclosed herein may also be utilized with rigs used for drilling offshore wellbores. A rotary table **169** or a top drive (not shown) coupled to the drill string **118** at the surface may be utilized to rotate the drill string **118** and thus the drilling assembly **130** and the drill bit **150** to drill the wellbore **110**. A drilling motor **155** (also referred to as "mud motor") may also be provided to rotate the drill bit. A control unit (or controller) **170** in the BHA **130** may be configured to receive and process data from the sensors **160** in the drill bit **150** and sensors **175** in the drilling assembly **130** and to control selected operations of the various devices and sensors in the drilling assembly **130**. The controller **170** may include a processor **172**, such as a microprocessor, a data storage device **174** and programs **176** for use by the processor **170** to process the data from the sensors **160** and **175**. Also, a controller **190**, which may be a computer-based system, may be placed at the surface **167** for receiving and processing data transmitted by the sensors in the drill bit and sensors **175** in the drilling assembly **130** and for controlling selected operations of the various devices and sensors in the drilling assembly **130**. The surface controller **190**, in one embodiment, may include a processor **192**, a data storage device (or a computer-readable medium) **194** for storing data and computer programs **196**. The data storage devices **174** and **194** may be any suitable devices, including, but not limited to, a read-only memory (ROM), a random-access memory (RAM), a flash memory, a magnetic tape, a hard disc and an optical disk. To drill a wellbore, a drilling fluid from a source **179** is pumped under pressure into the tubular member **116**. A telemetry unit **188** in the BHA provides two-way communication between the BHA and the surface controller **190**. During drilling, the drilling fluid discharges at the bottom of the drill bit **150** and returns to the surface via the annular space (also referred as the "annulus") between the drill string **118** and the inside wall of the wellbore **110**.

Still referring to FIG. **1**, drill bits, such as drill bit **150**, commonly include a threaded pin connection at its top end that is connected to a box end at the bottom of the BHA **130**. The box end includes internal threads that complement the threads on the drill bit pin connection. Mating the box end with the pin end provides a fixed connection between the BHA and the drill bit **150**. Such a connection is not conducive to providing a direct path for conductors from the drill bit **150** to the BHA **130**. Therefore, electrical communication between the drill bit **150** and the data bus in the BHA **130** are either not provided or in some cases, electrical coupling rings are used at the box end and at a neck portion of the pin connection, which coupling rings come in contact with each other when the box end mates with the pin end, thereby providing an electrical path between the drill bit **150** and the BHA **130**. In the configuration shown in FIG. **1**, a direct data and power connection between the drill bit **150** and the BHA **130** is provided via a communication link **154**. The details of an exemplary communication link **154** are described in reference to FIGS. **4-6**.

FIG. **2** shows a perspective view of an exemplary drill bit **150**. The drill bit **150** shown is a PDC (polycrystalline diamond compact) drill bit for the purposes of explaining the concepts described herein. However, any other type of drill bit may be utilized for the purpose of this disclosure. The drill bit **150** is shown to include a drill bit body **212** comprising a crown **212***a* and a shank **212***b*. The crown **212***a* includes a number of blade profiles (or profiles) **214***a*, **214***b*, . . . **214***n*. A number of cutters are placed along each profile. For example, profile **214***n* is shown to contain cutters **216***a*-**216***m*. All profiles are shown to terminate at the bottom **215** of the drill bit **150**. Each cutter has a cutting surface or cutting element, such as element **216***a*' of cutter **216***a*, that engages the rock formation when the drill bit **150** is rotated during drilling of the wellbore. The drill bit **150** includes a neck or pin connection **212***c* having external threads **212***d*. The BHA connects to the pin section **212***c* via a box section having internal threads compliant with the threads **212***d*. One or more sensors, such as sensors **240***a*, **2420**, **240***c*, placed in the drill bit body generate measurement signals that may be processed by circuits in the drill bit **150** and transmitted to the BHA **130** or transmitted to the BHA by the direct communication link **154** (FIG. **1**) as described in more detail in reference to FIGS. **3-6**.

FIG. **3** shows a transparent perspective view of the shank **212***b* and the pin section **212***c* of the drill bit **150** shown in FIG. **2**. The shank **212***b* includes a bore **310** therethrough for supplying drilling fluid **313** to the crown **212***a* (FIG. **2**) of the drill bit **150**. The upper end **312** of the neck section **212***c* includes a recess section **318** for housing therein the communication link **154** (FIG. **1**) and electronics **250** for processing signals from the various sensors **240***a*, **240***b*, **240***c* (collectively sensors **240**) in the drill bit **150**. Threads **319** on the neck section **312** connect the drill bit **150** to the drilling assembly **130** (FIG. **1**) as described before. Power to and measurement signals from the sensors **240** may be communicated between the recess **318** via conductors (electrical, fiber optic, etc.) **242** placed in a bore **332** in the shank **212***b* between the sensors **240** and the bottom **318***a* of the recess **318**.

FIG. **4** is a perspective view of an exemplary communication device or a communication link **400** configured to provide direct communication link between two connecting members, including, but not limited to, drill bit **150** and BHA **130** (FIG. **1**) and adjacent drill pipe sections. The communication link **400** shown is configured as a double spool that includes a lower section **402** and an upper section **404**. In one aspect, the lower and upper sections **402**, **404** may be mirror images of each other, as shown in FIG. **4**. The section **402** is shown to include a lower recess or first recess section **412***a*, a middle recess or second recess section **412***b* and an upper recess or third recess section **412***c*. Similarly, the upper section **404** includes a lower recess section **414***a*, a middle recess section **414***b* and an upper recess section **414***c*. In the embodiment shown, the middle recess sections **412***b* and **414***b* abut against each other and may be made of the same or different dimensions. In one aspect, the outer dimension or diameter **422***b* of the middle recess section **412***b* is greater than the outer diameter **422***a* of the lower recess section **412***a*, while the outer diameter **424***b* of the middle recess section **414***b* is greater than the outer diameter **424***a* of the lower recess section **414***a*. The middle recess sections **412***b* and **414***b*, in one embodiment, are configured to contain electrical circuits and processors configured to process signals generated by the sensors **240** in the drill bit **150** (FIGS. **2** and **3**). The recess sections **412***a*, **412***c*, **414***a* and **414***c* are configured to contain separate seals, such as o-rings configured to fluidly seal the communication link **400** at one end from a first member, such as the drill bit **150**, and at the second end from a connecting member, such as a box end at the end of the BHA **130** (FIG. **1**). One or more bores, such as bore **420**, may be formed from a flange surface **434***b* of the middle recess section **412***b* to a flange surface **444***b* of the middle recess section **414***b*. The bores **420** are of a size suitable to run conductors, such as electrical conductors and optical fibers therethrough. The location of the bores **420**, in one configuration, is outside the diameters **422***a* and **424***a* so that conductors can be run directly from below the lower recess section **412***a* to the bore **420** and then from the bore **420** to a location above the lower recess **414***a*, as described in more detail in reference to FIG. **5**. In an embodiment, a bottom facet **435** of section **402** has an anti-rotational feature that would keep the communication link **400** from rotating when the box end **562** of tool **560** screwed onto pin section **502**. An exemplary anti-rotational feature may be alternating surface heights of the bottom facet

435 (such as that shown for the surface across diameter **424***a*) and/or non-rounded (e.g., elliptical, hex, rectangular) geometry of the bottom facet **435**. In the example, the spool section **402** with the anti-rotational feature is connected to the bit first, the box end of the tool is then connected to the pin of the bit, and concurrently connected or mated with the spool.

FIG. **5** shows an assembly **500**, wherein a pin section **502** of a drill bit **510** is coupled to a box end **562** of a tool **560**, with one section **402** of a communication link **400** placed within the pin section **502** of the drill bit **510** and the other section **402***b* placed within the box end **562** of the tool **560** to provide a direct communication link between the drill bit **510** and the tool **560**. A communication link or device, including, but not limited to device **400**, placed between adjoining members configured to provide a direct communication link between the adjoining members may be referred to as a "communication sub" or "sub." The adjoining members may be any suitable members, including, but not limited to, two tubular members, such as drill pipe sections, a drill bit and a BHA, a BHA and a tubular, and two downhole tools.

In the configuration shown in FIG. **5**, the pin section **502** is shown to include a recess **512** having a lower or smaller recess **512***a* of diameter d**1** and an upper or larger recess **512***b* of diameter d**2**. The box end **562** includes the same recess structure as the pin section **502**. As shown, the box end **562** includes a recess **572** having a lower or smaller recess **572***a* of diameter d**1** and an upper or larger recess **572***b* of diameter d**2**. To form the assembly **500**, a sealing member **514***a* is placed in the recess **412***a* and a sealing member **514***c* is placed in the recess **412***c* of the communication link **400**. The lower section **402** of the communication link **400** is then placed inside the recess **512***a* so that the seal **514***a* seals the recess **412***a* against the wall **516***a* of the recess **512***a* and the seal **514***c* seals the recess **412***c* against the inside wall **516***b* of the recess **512***b*. This ensures that the lower section **402** of the communication sub **400** is secured airtight in the pin connection.

Still referring to FIG. **5**, before placing the communication link **400** in the pin section **502**, conductors **522** (electrical wires, optical fibers, etc.) are run from the sensors **520** in the drill bit **510** to the cavity **512** in the pin section via a conduit or cavity **524** in the drill bit **510**. A connector **526** may be used to connect the conductors **522** to a circuit **530** placed in or around the middle recess **410***b* of the section **402** of the communication link **400**. Conductors **528** from the circuit **530** are run through the bore **420** in the communication link **400** so that conductors **528** are available for connection to the circuits **540** in the recess section **414***b* and/or the BHA **130** as described below. Once the conductors **522** have been run through the bore **420**, the lower section **402** of the communication link **400** may be placed in cavity **512**. The conductors **528** are then connected to the circuit **540**. The conductors **541** from the circuit are then run through the bore or conduit **568** in the box section **562** to the BHA. Alternatively or in addition to conductors **522** from the drill bit **510** may be run to the BHA **130** via the bore **420** and bore **568**. Such configurations provide direct connection of the conductors **522**, **528** and **541** from the drill bit **510** to the BHA. The conductors **522**, **528** and **541**, as the case may be, can carry large amounts of data to a suitable circuit and processor in the BHA. Also, conductors can be run from the BHA **130** to the circuits **530**, **540** and sensors **520** to provide power and to provide two-way communication with such elements. Direct communication between the drill bit **510** and the BHA **130** eliminates the need for batteries in the drill bit and the use of delicate electronic circuits, including microprocessors, because such elements can be placed in the BHA sections where more space is available and which sections may be less susceptible to vibrations compared to the drill bit. Once all the conductors have been run as desired, the box end **562** of the tool **560** is then screwed onto the pin section **502**. Seals **572***a* and **572***c* respectively provide airtight connections between the box end **562** and the lower recess **414***a* and the upper recess **414***c*.

FIG. **6** shows an exemplary auto-retrievable device **600** that may be used to connect the conductors **541** from the communication link **400** to conductors that run to the BHA **130**. In one aspect, the auto-retrievable device **600** includes a connector **602** that is connected to the conductors **541**. A conductor **604**, connected to a storage spool **606** that includes a retraction device **608**, is wound around the recess section **414***b* in a manner that when the box end **562** is screwed on to the pin section **502**, the conductor **604** will be retracted into the spool **606**. The conductors to and from the BHA **130** are connected to a connector **620**.

The foregoing description is directed to particular embodiments for the purpose of illustration and explanation. It will be apparent, however, to persons skilled in the art that many modifications and changes to the embodiments set forth above may be made without departing from the scope and spirit of the concepts and embodiments disclosed herein. It is intended that the following claims be interpreted to embrace all such modifications and changes.

The invention claimed is:

1. An apparatus for use in a wellbore, comprising:

a drill bit;

a tool attached to the drill bit, wherein a cavity is formed between the drill bit and the tool; and

a communication device in the cavity, the communication device including a first section having a flange surface and a second section have a flange surface and a bore through the flange surface of the first section and the flange surface of the second section, offset from a center of the communication device that allows passage of a conductor from the drill bit to the tool to provide direct communication between the drill bit and the tool.

2. The apparatus of claim **1**, wherein the cavity comprises a first cavity in the drill bit and second cavity in the tool.

3. The apparatus of claim **2**, wherein the first section is placed in the first cavity in the drill bit and the second section placed is in the second cavity in the tool.

4. The apparatus of claim **2**, wherein the first cavity is in a pin section of the drill bit and the second cavity is in a box section of the tool.

5. The apparatus of claim **3**, wherein an outer dimension of the second section is greater than an outer dimension of the first section and wherein the bore is formed in the second section.

6. The apparatus of claim **3**, further comprising a pressure seal between the first cavity in the drill bit and the communication device and a pressure seal between the second cavity in the tool and the communication device.

7. The apparatus of claim **3**, wherein the communication device further includes a third section placed in the second cavity in the tool and wherein the first section, second section and third section form a double spool configured to provide a pressure tight first cavity and a pressure tight second cavity.

8. The apparatus of claim **3** further comprising a first circuit in the first section of the communication device configured to process signals from a sensor in the drill bit and wherein the conductor is coupled to the first circuit in the first section and a second circuit in the second section.

9. The apparatus of claim **1** further comprising a sensor in the drill bit that provides signals relating to a parameter of interest when the drill bit is used to drill a wellbore.

10. The apparatus of claim **1** further comprising a retrievable device connected to the conductor passing through the bore, wherein the retrievable device is configured to enable the tool to be rotatably attached to the drill bit.

11. A method of performing a wellbore operation, comprising:

coupling a drill bit having a first cavity at an upper section of the drill bit to a tool having a second cavity at a lower end of the tool to form a common cavity between the drill bit and the tool; and

placing a communication device in the common cavity, the communication device including a first section having a flange surface and a second section have a flange surface and a bore through the flange surface of the first section and the flange surface of the second section, offset from a center of the communication device that enables passage of a conductor between the drill bit and the tool to provide direct communication between the drill bit and the tool.

12. The method of claim **11**, wherein the first section is placed in the first cavity in the drill bit and the second section is placed in the first cavity in the drill bit and the second cavity in the tool.

13. The method of claim **12**, wherein an outer dimension of the second section is greater than an outer dimension of the first section and wherein the bore is formed in the second section.

14. The method of claim **13** further comprising providing a pressure seal between the first cavity in the drill bit and the communication device and a pressure seal between the second cavity in the tool and the communication device.

15. The method of claim **13**, wherein the communication device further includes a third section placed in the second cavity in the tool and wherein the first section, second section and third section form a double spool configured to provide the pressure seal between the first cavity and the drill bit and the communication device and the pressure seal between the second cavity in the tool and the communication device.

16. The method of claim **11** further comprising providing a sensor in the drill bit that provides signals relating to a parameter of interest when the drill bit is used to drill a wellbore.

17. The method of claim **12** further comprising providing a first circuit in the first section configured to process signals from a sensor in the drill bit and coupling the conductor to the first circuit in the first section and a second circuit in the tool.

18. The method of claim **11**, wherein the first cavity is in a pin section of the drill bit and the second section is in a box section of the tool.

19. The method of claim **11** further comprising connecting a device to the conductor passing through the bore configured to enable the tool to connect to the drill bit by rotating the tool onto the drill bit.

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